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(54) **GAMING DEVICE WITH A VIRTUALIZATION MANAGER**

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G07F 17/32 (2006.01)
G06F 9/455 (2006.01)

(52) **U.S. Cl.**
CPC ***G07F 17/32*** (2013.01); ***G06F 9/45558*** (2013.01)

(58) **Field of Classification Search**
USPC 463/16; 718/1
See application file for complete search history.

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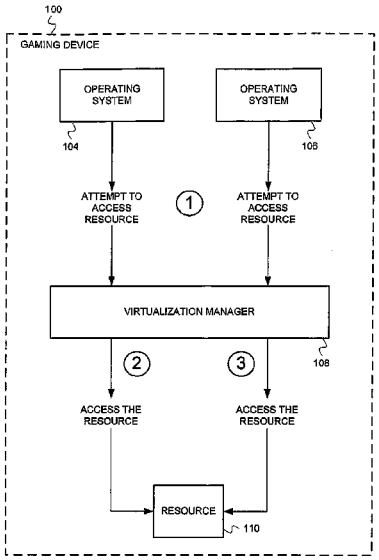
(57) **ABSTRACT**

Gaming devices with virtualization managers are described herein. In one embodiment, a gaming device includes a plurality of operating systems, each of the operating systems to facilitate execution of one or more gaming applications. The gaming device also includes gaming device resources for use by ones of the plurality of operating systems and a virtualization manager to share the gaming device resources between the plurality of operating systems during virtually simultaneous execution of the plurality of operating systems.

20 Claims, 11 Drawing Sheets



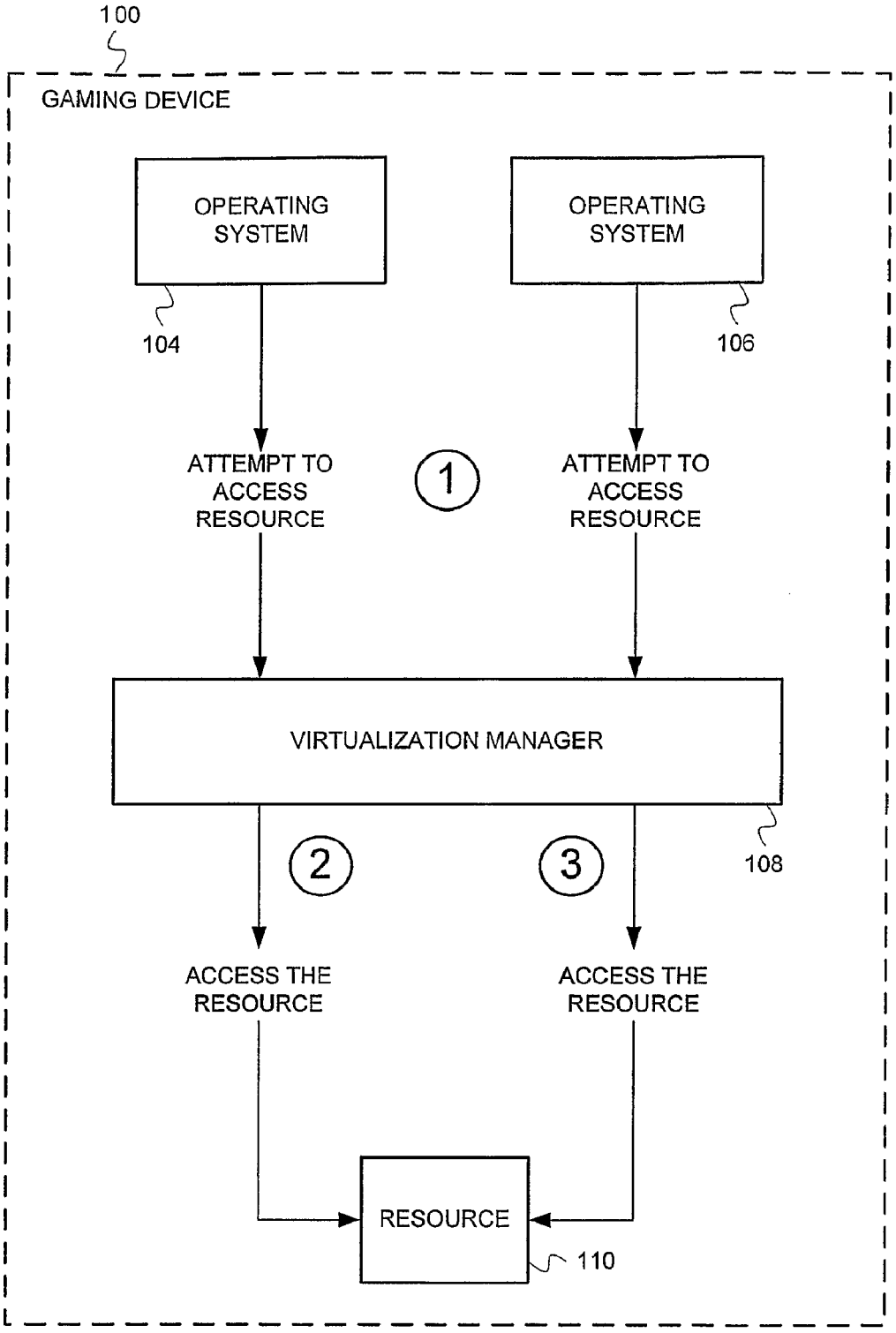

100
GAMING DEVICE
OPERATING SYSTEM
OPERATING SYSTEM
104
106
ATTEMPT TO ACCESS RESOURCE
1
ATTEMPT TO ACCESS RESOURCE
VIRTUALIZATION MANAGER
108
2
3
ACCESS THE RESOURCE
ACCESS THE RESOURCE
RESOURCE
110

FIG. 1

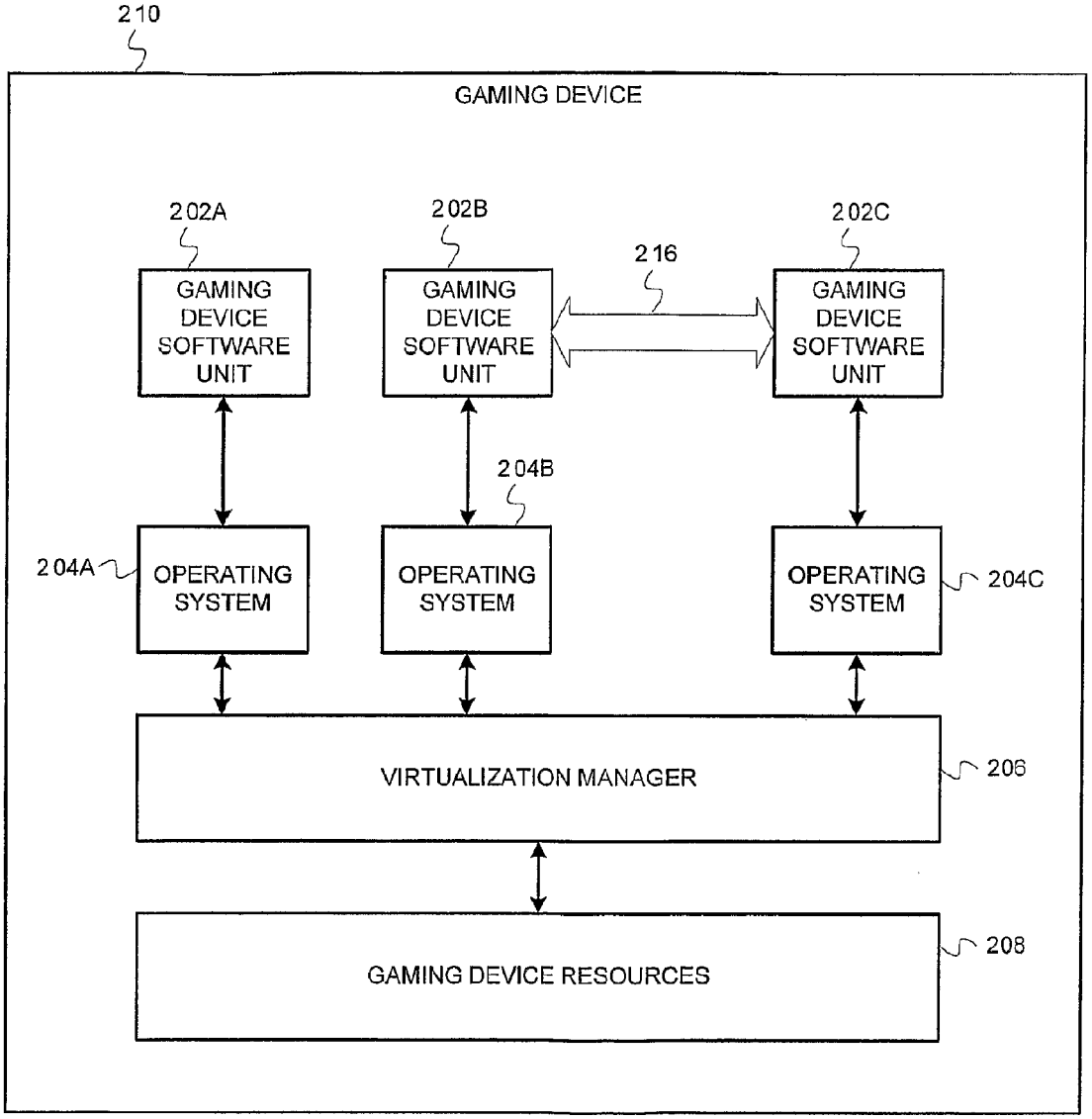

210
GAMING DEVICE
202A
202B
202C
216
GAMING DEVICE SOFTWARE UNIT
GAMING DEVICE SOFTWARE UNIT
GAMING DEVICE SOFTWARE UNIT
204B
204A
OPERATING SYSTEM
OPERATING SYSTEM
OPERATING SYSTEM
204C
VIRTUALIZATION MANAGER
206
GAMING DEVICE RESOURCES
208

FIG. 2

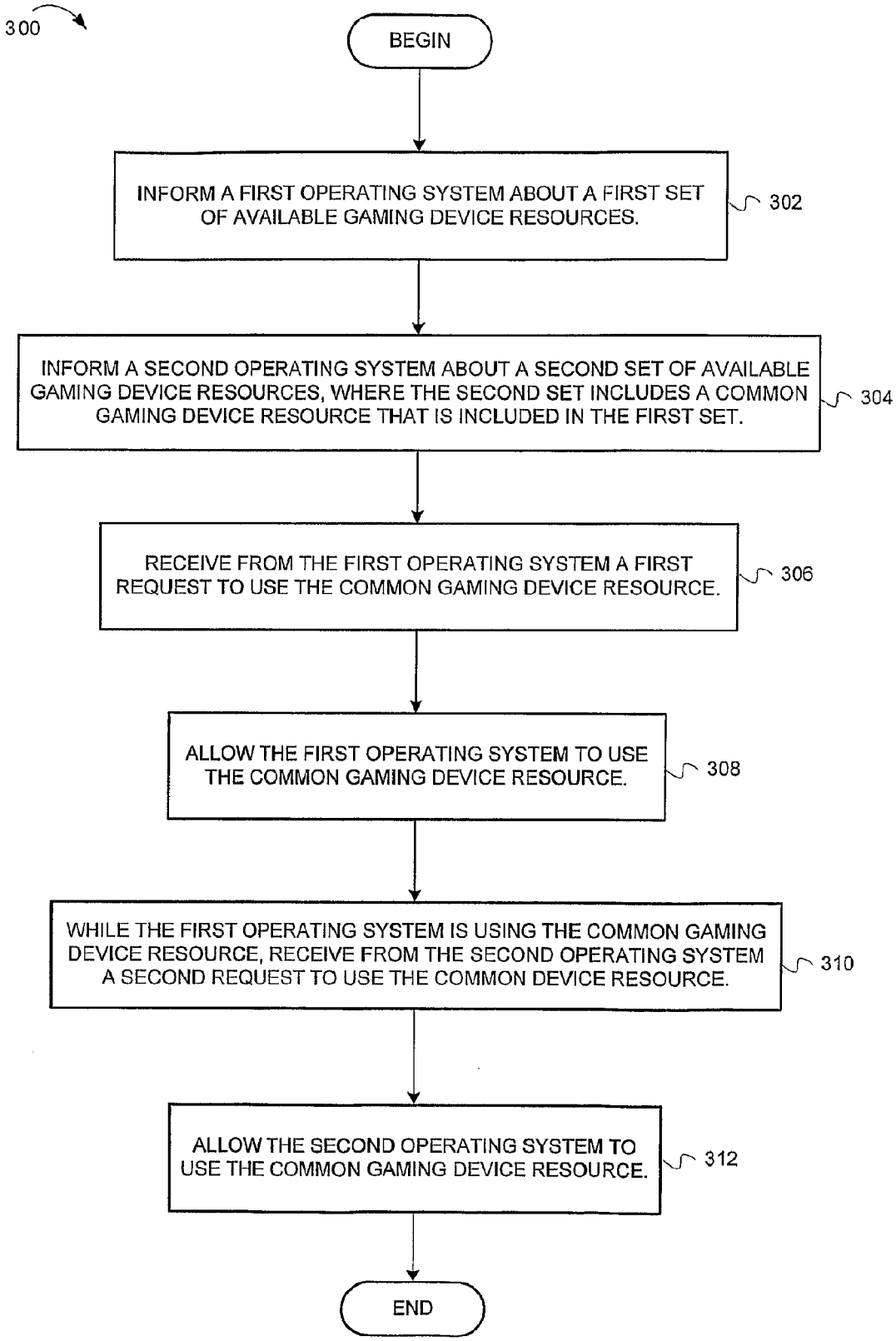

300
BEGIN
INFORM A FIRST OPERATING SYSTEM ABOUT A FIRST SET OF AVAILABLE GAMING DEVICE RESOURCES.
302
INFORM A SECOND OPERATING SYSTEM ABOUT A SECOND SET OF AVAILABLE GAMING DEVICE RESOURCES, WHERE THE SECOND SET INCLUDES A COMMON GAMING DEVICE RESOURCE THAT IS INCLUDED IN THE FIRST SET.
304
RECEIVE FROM THE FIRST OPERATING SYSTEM A FIRST REQUEST TO USE THE COMMON GAMING DEVICE RESOURCE.
306
ALLOW THE FIRST OPERATING SYSTEM TO USE THE COMMON GAMING DEVICE RESOURCE.
308
WHILE THE FIRST OPERATING SYSTEM IS USING THE COMMON GAMING DEVICE RESOURCE, RECEIVE FROM THE SECOND OPERATING SYSTEM A SECOND REQUEST TO USE THE COMMON DEVICE RESOURCE.
310
ALLOW THE SECOND OPERATING SYSTEM TO USE THE COMMON GAMING DEVICE RESOURCE.
312
END

FIG. 3

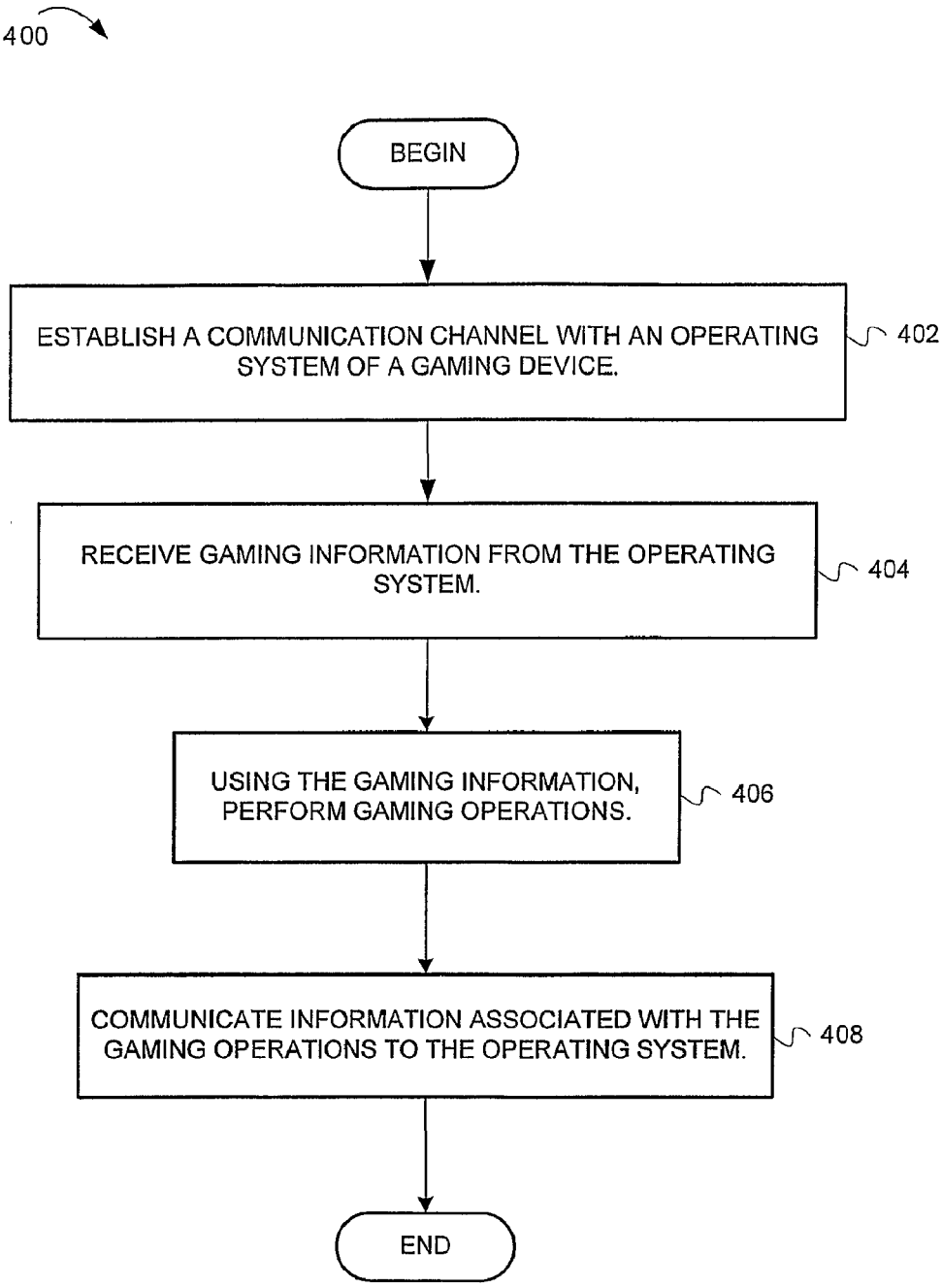

400
BEGIN
ESTABLISH A COMMUNICATION CHANNEL WITH AN OPERATING SYSTEM OF A GAMING DEVICE.
402
RECEIVE GAMING INFORMATION FROM THE OPERATING SYSTEM.
404
USING THE GAMING INFORMATION, PERFORM GAMING OPERATIONS.
406
COMMUNICATE INFORMATION ASSOCIATED WITH THE GAMING OPERATIONS TO THE OPERATING SYSTEM.
408
END

FIG. 4

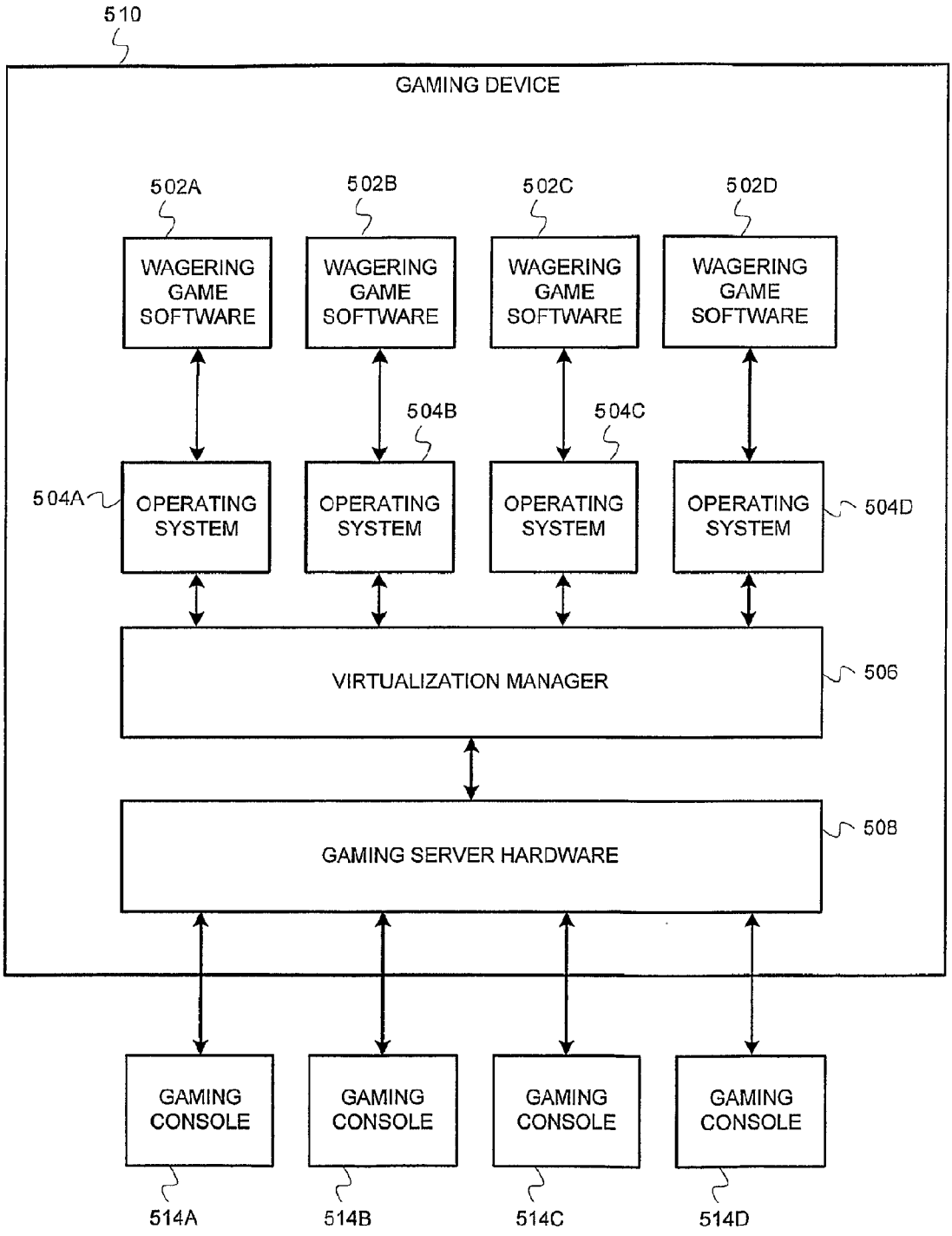

510
GAMING DEVICE
502A
502B
502C
502D
WAGERING GAME SOFTWARE
WAGERING GAME SOFTWARE
WAGERING GAME SOFTWARE
WAGERING GAME SOFTWARE
504A
504B
504C
504D
OPERATING SYSTEM
OPERATING SYSTEM
OPERATING SYSTEM
OPERATING SYSTEM
VIRTUALIZATION MANAGER
506
GAMING SERVER HARDWARE
508
GAMING CONSOLE
GAMING CONSOLE
GAMING CONSOLE
GAMING CONSOLE
514A
514B
514C
514D

FIG. 5

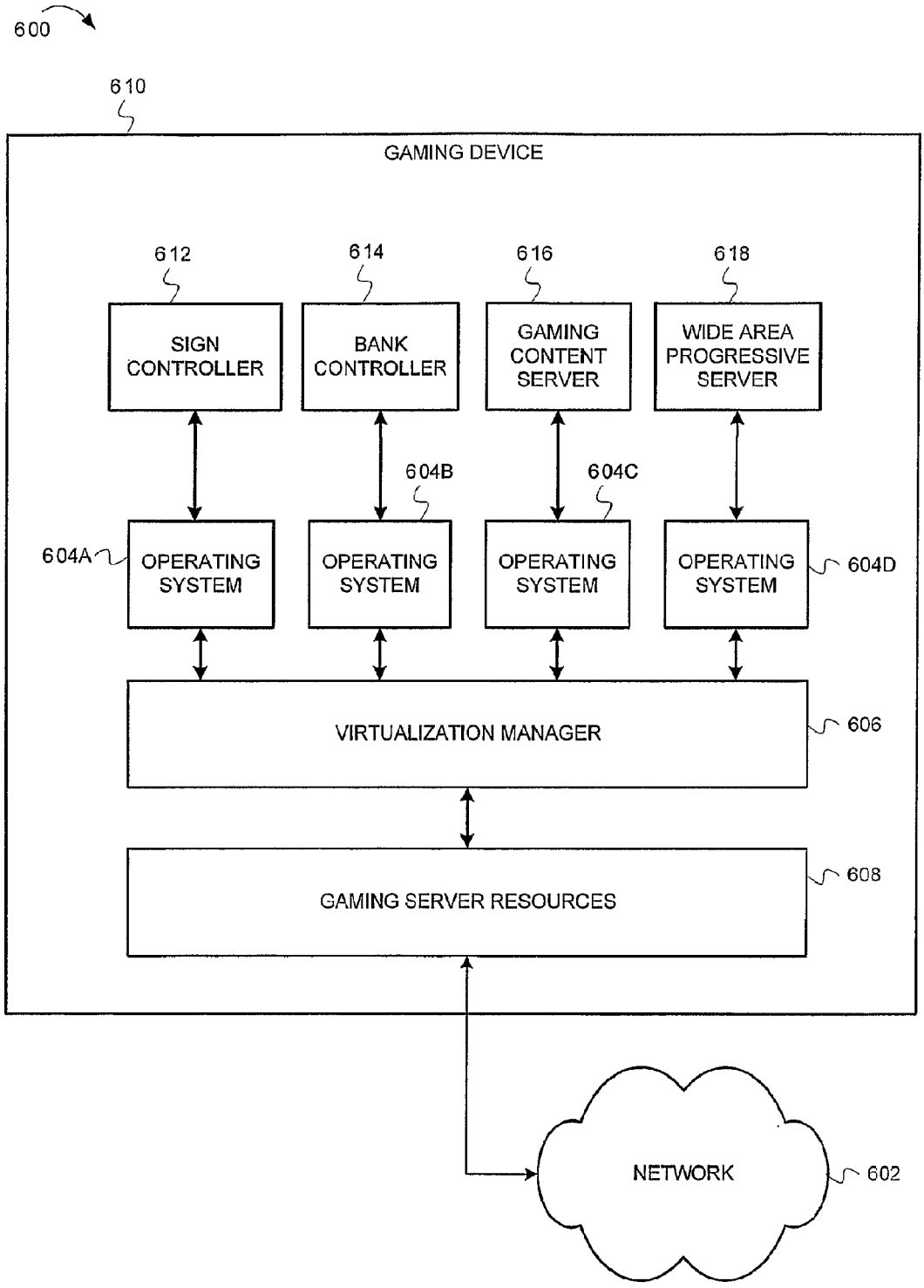

600
610
GAMING DEVICE
612
614
616
618
SIGN CONTROLLER
BANK CONTROLLER
GAMING CONTENT SERVER
WIDE AREA PROGRESSIVE SERVER
604A
604B
604C
604D
OPERATING SYSTEM
OPERATING SYSTEM
OPERATING SYSTEM
OPERATING SYSTEM
VIRTUALIZATION MANAGER
606
GAMING SERVER RESOURCES
608
NETWORK
602

FIG. 6

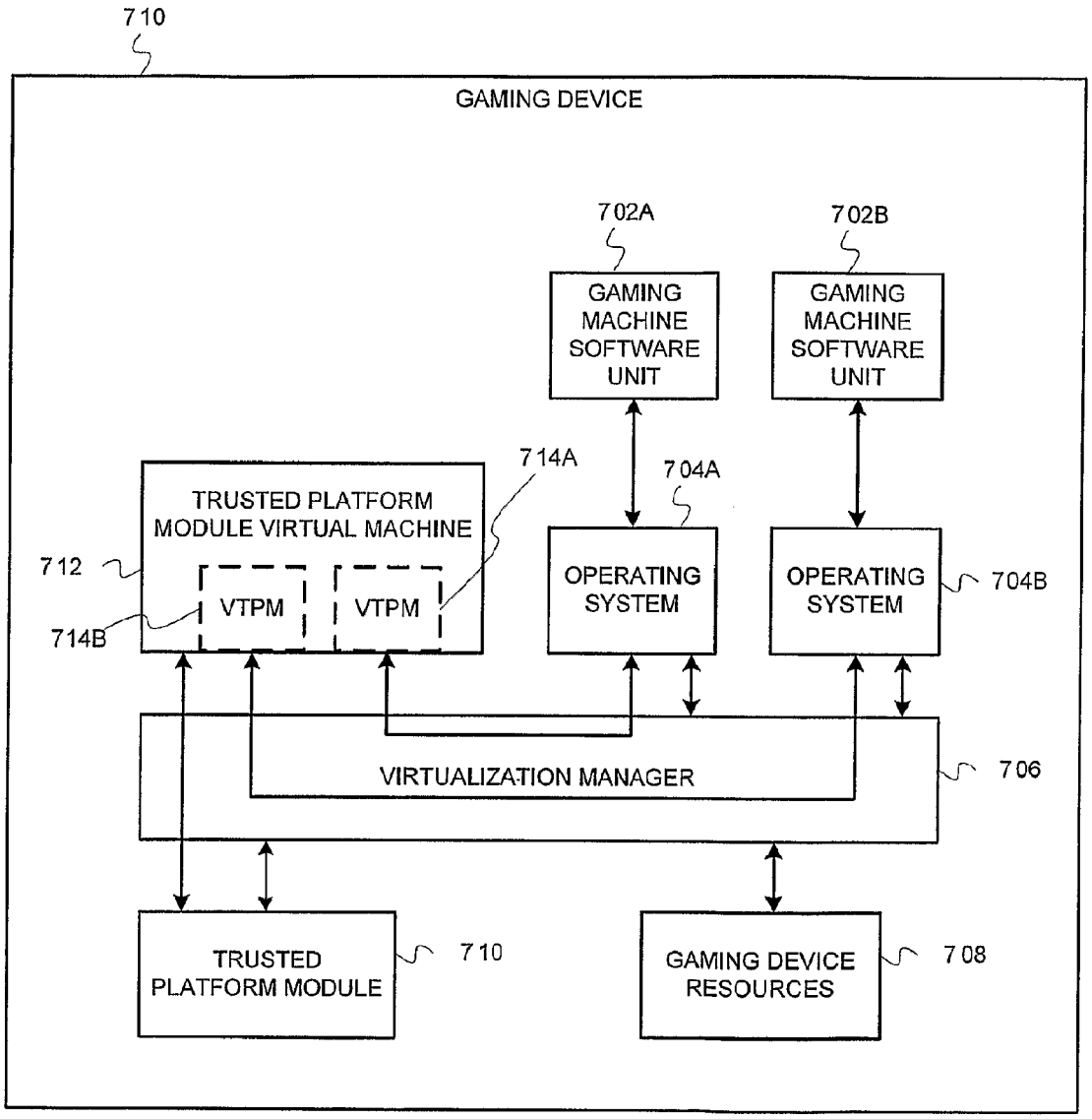

710
GAMING DEVICE
702A
702B
GAMING MACHINE SOFTWARE UNIT
GAMING MACHINE SOFTWARE UNIT
714A
704A
TRUSTED PLATFORM MODULE VIRTUAL MACHINE
712
VTPM
VTPM
714B
OPERATING SYSTEM
OPERATING SYSTEM
704B
VIRTUALIZATION MANAGER
706
TRUSTED PLATFORM MODULE
710
GAMING DEVICE RESOURCES
708

FIG. 7

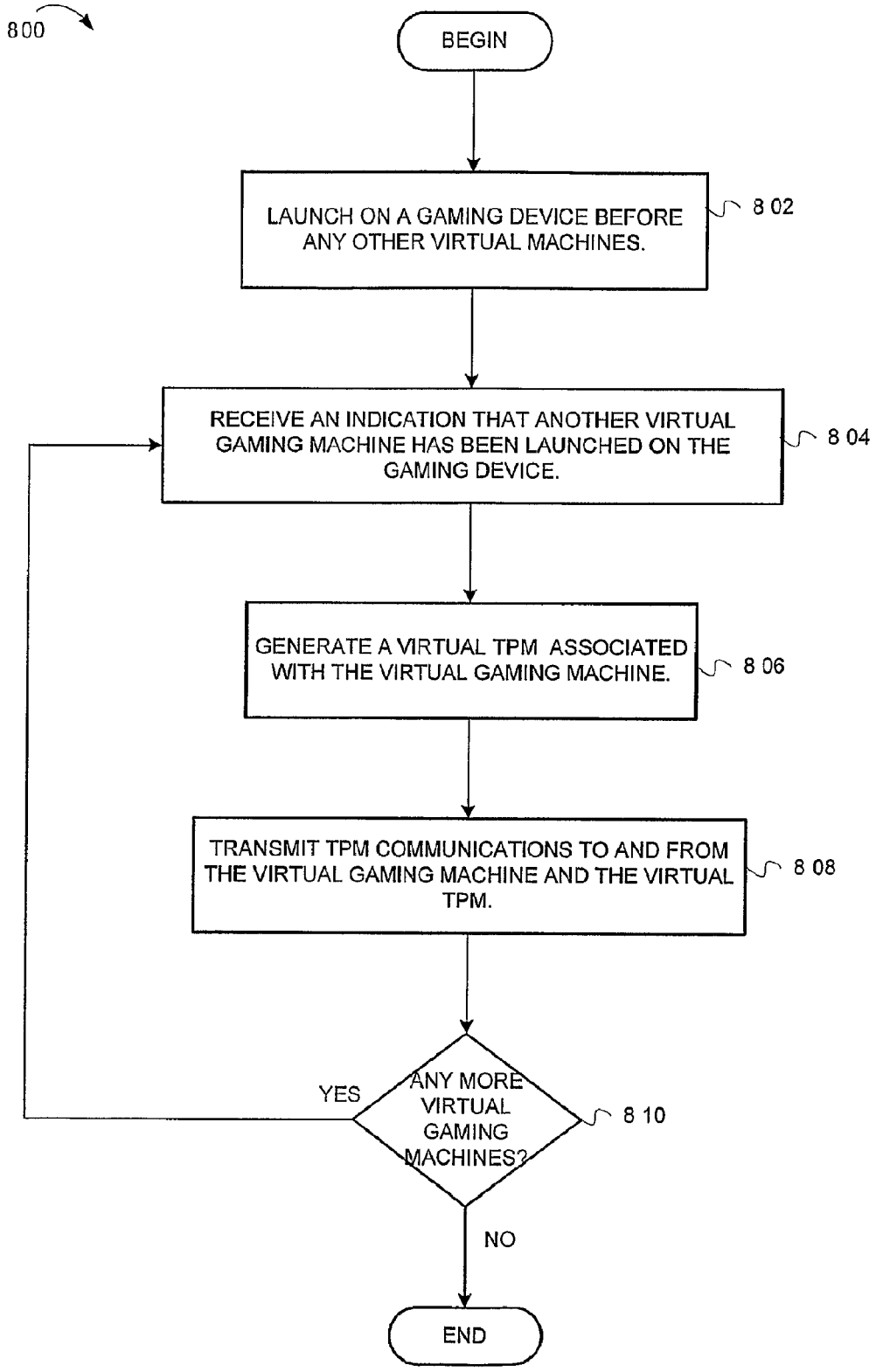

800
BEGIN
LAUNCH ON A GAMING DEVICE BEFORE ANY OTHER VIRTUAL MACHINES.
8 02
RECEIVE AN INDICATION THAT ANOTHER VIRTUAL GAMING MACHINE HAS BEEN LAUNCHED ON THE GAMING DEVICE.
8 04
GENERATE A VIRTUAL TPM ASSOCIATED WITH THE VIRTUAL GAMING MACHINE.
8 06
TRANSMIT TPM COMMUNICATIONS TO AND FROM THE VIRTUAL GAMING MACHINE AND THE VIRTUAL TPM.
8 08
ANY MORE VIRTUAL GAMING MACHINES?
8 10
YES
NO
END

FIG. 8

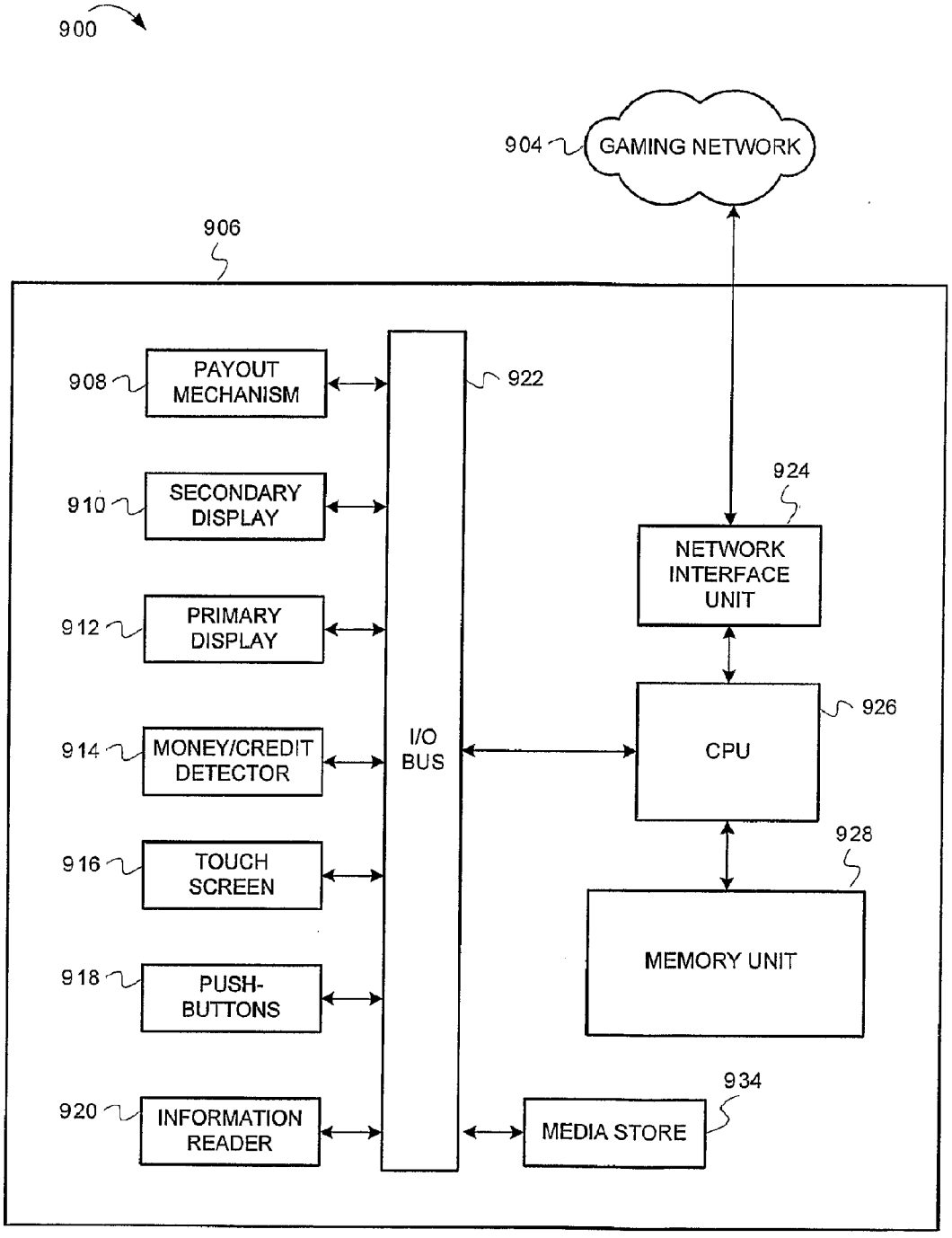

900
904
GAMING NETWORK
906
908
PAYOUT MECHANISM
922
910
SECONDARY DISPLAY
924
NETWORK INTERFACE UNIT
912
PRIMARY DISPLAY
914
MONEY/CREDIT DETECTOR
I/O BUS
926
CPU
916
TOUCH SCREEN
928
MEMORY UNIT
918
PUSH-BUTTONS
934
920
INFORMATION READER
MEDIA STORE

FIG. 9

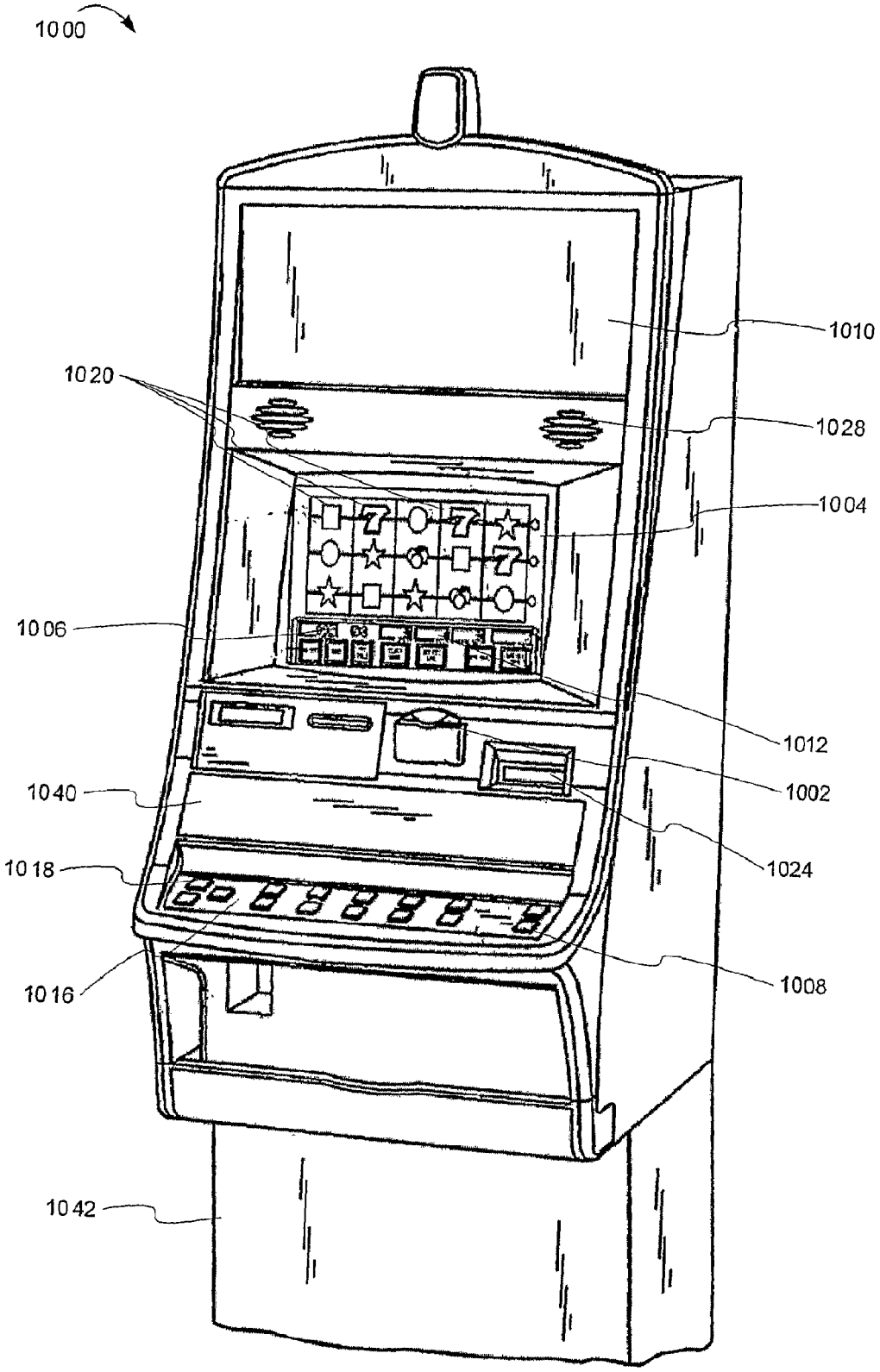

1000
1010
1020
1028
1004
1006
1012
1002
1040
1024
1018
1008
1016
1042

FIG. 10

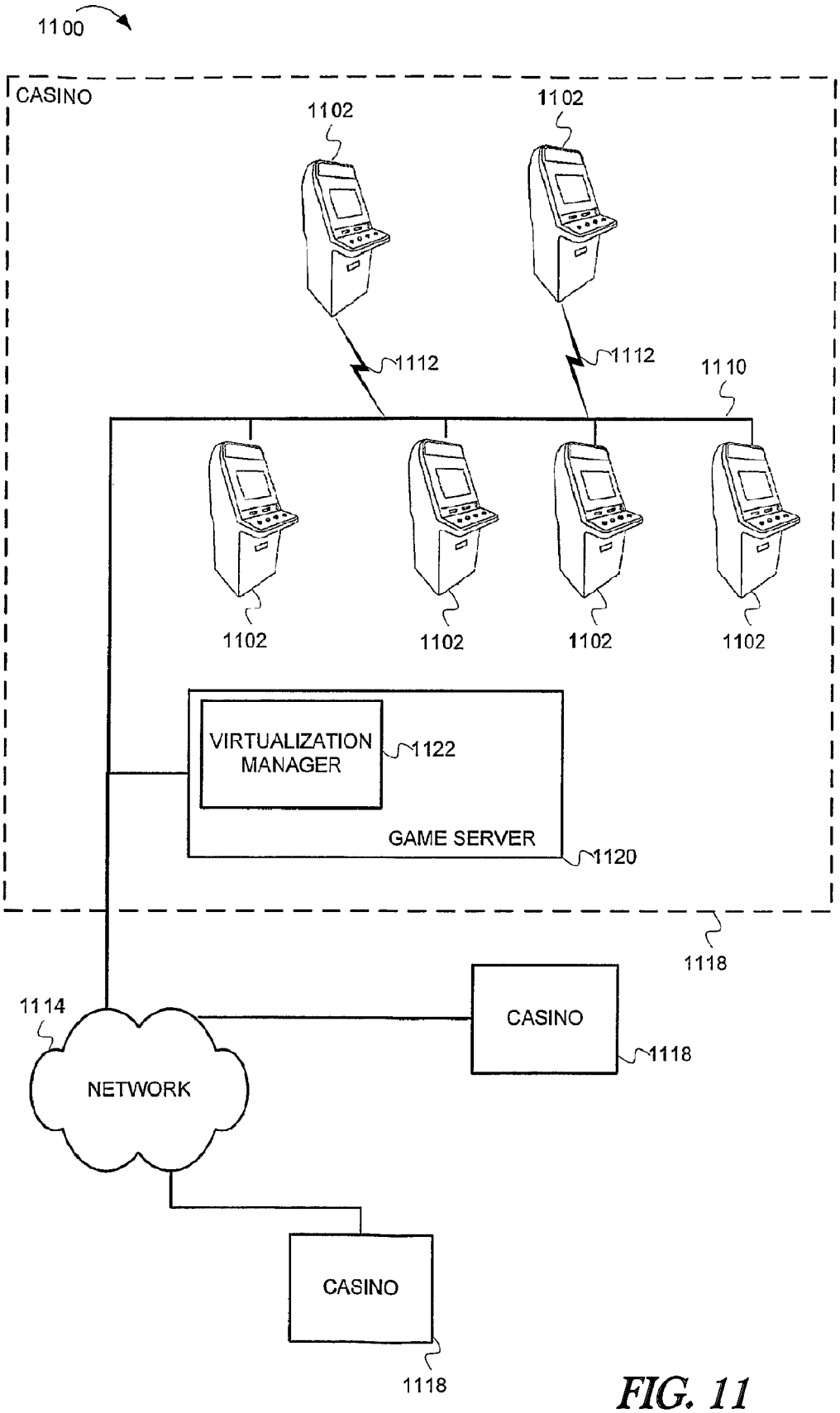

1100
CASINO
1102
1102
1112
1112
1110
1102
1102
1102
1102
VIRTUALIZATION MANAGER
1122
GAME SERVER
1120
1118
1114
NETWORK
CASINO
1118
CASINO
1118

FIG. 11

GAMING DEVICE WITH A VIRTUALIZATION MANAGER

RELATED APPLICATIONS

This application is a U.S. National Stage Filing under 35 U.S.C. 371 from International Patent Application Ser. No. PCT/US2006/034600, filed Sep. 6, 2006, and published on Mar. 15, 2007 as WO 2007/030472 A2 and republished as WO 2007/030472 A3, which claims the priority benefit of U.S. Provisional Application Ser. No. 60/715,520 filed Sep. 9, 2005 and U.S. Provisional Application Ser. No. 60/749,334 filed Dec. 9, 2005, the contents both of which are incorporated herein by reference in their entirety.

LIMITED COPYRIGHT WAIVER

FIELD

This invention relates generally to the field of gaming devices and more particularly to the field of sharing resources between operating systems in gaming devices.

BACKGROUND

Wagering game networks can include numerous gaming machines and servers for performing a multitude of gaming functions, such as conducting wagering games and tracking money collected and awarded. Gaming servers (e.g., accounting servers, wide area progress servers, etc.) are typically configured with hardware and software for tracking and/or distributing data throughout a gaming network. The gaming servers typically provide services by executing multiple application programs on a single multi-tasking operating system. Multi-tasking operating systems, such as Linux and MS-Windows, share system resources (e.g., disk drives, memory, etc.) between multiple application programs, thereby enabling gaming devices to run multiple application programs virtually simultaneously within a single operating system in a gaming device.

BRIEF DESCRIPTION OF THE FIGURES

The present invention is illustrated by way of example and not limitation in the Figures of the accompanying drawings in which:

FIG. **1** is a diagrammatic illustration of multiple operating systems sharing a resource in a gaming device, according to exemplary embodiments of the invention;

FIG. **2** is a block diagram illustrating a gaming device, according to example embodiments of the invention;

FIG. **3** is a flow diagram illustrating operations for sharing resources between multiple operating systems in a gaming device, according to example embodiments of the invention;

FIG. **4** is a block diagram illustrating components of a gaming machine, used in conjunction with example embodiments of the invention;

FIG. **5** is a block diagram illustrating a gaming server, according to example embodiments of the invention;

FIG. **6** is a block diagram illustrating a plurality of gaming servers operating on a single gaming device, according to example embodiments of the invention;

FIG. **7** is a block diagram illustrating a gaming device including a virtualization manager and components for enhancing trust in the gaming device, according to example embodiments of the invention;

FIG. **8** is a flow diagram illustrating operations for launching and running a plurality of trusted virtual machines in a gaming device, according to example embodiments of the invention;

FIG. **9** is a block diagram illustrating components of a gaming device, used in conjunction with example embodiments of the invention;

FIG. **10** is a perspective view of a gaming machine, according to example embodiments of the invention; and

FIG. **11** is a block diagram illustrating a wagering game network, according to example embodiments of the invention.

DESCRIPTION OF THE EMBODIMENTS

Systems and methods for using virtualization managers in gaming devices are described herein. This description of the embodiments is divided into six sections. The first section provides an introduction to embodiments of the invention. The second section describes example gaming device architectures, while the third section describes example operations performed by some embodiments of the gaming device architectures. The fourth section describes additional gaming device embodiments and the fifth section describes gaming devices and gaming machines in greater detail. The sixth section provides some general comments.

Introduction

This section introduces embodiments of a gaming device including a virtualization manager for executing multiple operating systems. Embodiments of the invention enable a single gaming device to operate as multiple virtual gaming devices by facilitating resource sharing between a plurality of operating systems. For example, a single gaming device can operating as a wide area progressive server, gaming content download server, and accounting server. Furthermore, because embodiments enable gaming devices to run multiple operating systems virtually simultaneously, gaming machines can split operations for conducting a wagering game between applications running on two or more operating systems. For example, the gaming machine can perform a wagering game's input/output (I/O) operations using one operating system, while determining the wagering game's results using another operating system. FIG. **1** describes resource sharing in greater detail.

FIG. **1** is a diagrammatic illustration of multiple operating systems sharing a resource in a gaming device, according to exemplary embodiments of the invention. As shown in FIG. **1**, the gaming device **100** includes operating systems **104** and **106**, virtualization manager **108**, and resource **110**. The resource **110** can include hardware resources (e.g., disk drive, physical port, etc.) or virtual resources (e.g., virtual disk, virtual port, etc.). The virtualization manager **108** allows the operating systems **104** and **106** to run virtually simultaneously and to share the resource **110**. FIG. **1** shows three stages of resource sharing.

At stage **1**, the virtualization manager **108** detects both operating systems **104** and **106** attempting to access the resource **110**. The attempts can occur close in time. For

example, first operating system **104** and then operating system **106** may attempt to access the resource **110**. The attempts could also occur simultaneously.

At stage **2**, the virtualization manager **108** allows the operating system **104** to access the resource **110**. At stage **3**, the virtualization manager **108** allows the operating system **106** to access the resource **110**. The virtualization manager **108** can use any suitable resource allocation technique for determining an order in which the operating systems access the resource **110** (e.g., first come first serve, priority scheduling, etc.). Because embodiments allocate gaming device resources between multiple operating systems, each operating system can operate as if it is the only operating system using a gaming device's resources. Thus, a single gaming device can operate as multiple servers and a gaming machine can conduct a wagering gaming using applications running on a plurality of operating systems. These and other features will be described in more detail below. The next section describes example gaming devices in more detail.

Example Gaming Devices

FIG. **2** is a block diagram illustrating a gaming device, according to example embodiments of the invention. According to embodiments, gaming device **210** can operate as a gaming machine, gaming server, control server, and/or any other device in a gaming network.

As shown in FIG. **2**, the gaming device **210** includes a plurality of gaming device software units **202***a-c* and a plurality of operating systems **204***a-c*. Each of the operating systems **204***a-c* provides services to the gaming device software units and manages access to gaming device resources **208**. For example, the operating system **204***a* can be a Linux operating system, while the gaming device software unit **202***a* can include applications compatible with the Linux operating system. The other operating systems **204***b-c* can include the same Linux version, a different Linux version, or different operating systems altogether (e.g., MS-Windows, Solaris, etc.).

The gaming device **210** also includes a virtualization manager **206** and gaming device resources **208**. The virtualization manager **206** can, among other things, facilitate sharing of the gaming device resources **208** between the operating systems **204***a-c*. The gaming device resources **208** can include processors, disk drives, network interface devices, random access memory, video cards, audio cards, and/or any other suitable computer hardware. In one embodiment, the gaming device resources **208** include some or all of the hardware described below, in the discussion of FIG. **7**.

In one embodiment, a gaming device software unit operating with one operating system can communicate with a gaming device software unit operating with different operating systems of the gaming device **210**. As shown in FIG. **2**, the gaming device software unit **202***b* can establish a communications channel **216** with gaming device software unit **202***b* even though each gaming device software unit is executing on a different operating system. The communications channel can include a socket, shared memory, direct memory access channels, serial port connection, or any other suitable means for communication information between operating systems.

Operations performed by embodiments of the gaming device are described in the next section.

System Operations

This section describes operations performed by embodiments of the invention. In the discussion below, the flow diagrams will be described with reference to the block diagrams presented above. In certain embodiments, the operations are performed by instructions residing on machine-readable media (e.g., software), while in other embodiments, the operations are performed by hardware and/or other logic (e.g., digital logic).

FIGS. **3** and **4** are discussed below. FIG. **3** describes operations for sharing resources between multiple operating systems in a gaming device, while FIG. **4** describes operations for communicating between operating systems of a gaming device. This description will proceed with a discussion of resource sharing.

As noted above, embodiments of the virtualization manager can facilitate resource sharing between multiple operating systems. In one embodiment, the virtualization manager can share one or more processors between a plurality of operating systems **204**. For example, the virtualization manager **206** can cause the operating systems **204***a-c* to take turns executing on a set of one or more processors. When an operating system finishes its turn on the processor, the virtualization manager **206** can store state information, so the operating system can resume execution where it left off. As each operating system executes on a processor, the operating system can request and consume resources. FIG. **3** describes operations for sharing resources between a plurality of operating systems.

FIG. **3** is a flow diagram illustrating operations for sharing resources between multiple operating systems in a gaming device, according to example embodiments of the invention. Flow diagram **300** commences at block **302**.

At block **302**, a first operating system is informed about a first set of available gaming device resources. For example, when the virtualization manager **206** starts-up the operating system **204***a*, it informs the operating system **204***a* about a first set of resources included in the gaming device resources **208**. The first set can include a disk drive, video card, network interface, processor, etc. The flow continues at block **304**.

At block **304**, a second operating system is informed about a second set of available gaming device resources, where the second set of resources includes a common gaming device resource that is in both the first and second sets. For example, when the virtualization manager **206** starts-up the operating system **204***b*, it informs the operating system **204***b* about a second set of resources which includes a disk drive that is common to the first and second sets (i.e., the disk drive is available to both operating systems **204***a* and **204***b*). The flow continues at block **306**.

At block **306**, a request to use the common gaming device resource is received from the first operating system. For example, the virtualization manager **206** receives from the operating system **204***a* a request to read from the disk drive. The flow continues at block **308**.

At block **308**, the first operating system is allowed to use the common gaming device resource. For example, the virtualization manager **206** allows the operating system **204***a* to read from a disk drive. The flow continues at block **310**.

At block **310**, while the first operating system is using the common gaming device resource, a second request to use the common device resource is received from the second operating system. For example, while the operating system **204***a* is reading from the disk drive, the virtualization manager **206** receives from the operating system **204***b* a request to use a disk drive. The flow continues at block **312**.

At block **312**, the second operating system is allowed to use the gaming device resource. For example, the virtualization manager **206** allows the operating system **204***b* to write data to the disk drive. In one embodiment, the virtualization man-

ager **206** can use any suitable resource allocation method, such as first-come first-served allocation, priority allocation, priority allocation with preemption, etc. From block **312**, the flow ends.

While FIG. **3** describes resource sharing, FIG. **4** describes communicating data between operating systems. The discussion continues with FIG. **4**.

FIG. **4** is a flow diagram illustrating operations for communicating data between operating systems of a gaming device, according to example embodiments of the invention. The flow diagram **400** commences at block **402**.

At block **402**, a communication channel is established with an operating system of the gaming device. For example, the operating system **204***b* establishes a communication channel **216** with the operating system **204***c*. In one embodiment, the operating systems **204***a-c* can use any suitable method for establishing a communications channel. For example, they can use shared memory, direct memory access, and/or serial port connections.

In one embodiment, the virtualization manager **206** assigns different addresses to each operating system (e.g., an Internet Protocol address), so each operating system can transmit and receive data to the other operating systems over a virtual communication network. As a result, the operating systems **204***a-c* can use standard networking communication protocols for exchanging data. For example, the operating system **204***b* can establish a socket with operating system **204***c* and then transmit data to operating system **204***c* using TCP/IP protocols. In this embodiment, data transmissions between the operating systems **204***a-c* are relatively fast and reliable because the data never leaves the gaming device **210**. The flow continues at block **404**.

At block **404**, gaming information is received from the other operating system. For example, the operating system **204***b* receives gaming information from the operating system **204***c* through a socket or shared memory. The flow continues at block **406**.

At block **406**, using the gaming information, gaming operations are performed. For example, the gaming device software unit **202***b*, which is running on the operating system **204***b*, performs gaming operations based on the gaming information. In one embodiment, the gaming operations can include determining an outcome of the wagering game, performing wagering game I/O, performing wagering game accounting, forming wagering game security, etc. The flow continues at block **408**.

At block **408**, information associated with the gaming operations is communicated to the other operating system. For example, the operating system **204***b* communicates information associated with the gaming operations to the operating system **204***c*. In one embodiment, the information can include gaming outcome information, security information, accounting information, etc. From block **408**, the flow ends.

While this section described operations performed by embodiments of the invention, the next section describes additional embodiments of the invention.

Example Implementation

This section describes additional implementation details, according to example embodiments of the invention. In this section, the discussion of FIG. **5** describes a gaming device capable of conducting multiple wagering games, whereas the discussion of FIG. **6** describes multiple wagering game servers running on a single device. FIGS. **7** and **8** describe additional security features for embodiments of the virtualization manager.

Multiple Wagering Gaines

FIG. **5** is a block diagram illustrating a gaming server, according to example embodiments of the invention. As shown in FIG. **5**, the gaming server **510** includes wagering game software **502***a-d*, operating systems **504***a-d*, virtualization manager **506**, gaming server hardware **508**, and gaming consoles **514***a-d*.

In one embodiment, each gaming console works together with an operating system and wagering game software to conduct a wagering game. For example, gaming console **514***a*, operating system **504***a*, and wagering game software **502***a* work together to conduct one wagering game. In the embodiment shown in FIG. **5**, virtualization manager **506** enables the gaming server **510** to virtually simultaneously conduct four different wagering games. According to embodiments, the gaming server **510** can increase or decrease its ability to conduct wagering games by adding or removing gaming consoles, operating systems, and wagering game software.

In one embodiment, the gaming consoles **314***a-d* can be placed on a casino floor, while the gaming server **510** can be stored in a secure backroom. In one embodiment, the gaming consoles **314***a-d* are capable of processing wagering game I/O.

In one embodiment, the gaming server **510** can include additional wagering game software (not shown) running on one of the operating systems **504***a-d*. The additional wagering game software can determine outcomes of all the wagering games, while the wagering game software **502***a-d* can process wagering game I/O and present the wagering game results on the gaming consoles **314***a-d*. The additional wagering game software can communicate to the wagering game software **502***a-d* using the communication techniques described above (see FIG. **3**).

Multiple Gaming Servers

FIG. **6** is a block diagram illustrating a gaming device running plurality of gaming servers, according to example embodiments of the invention. As shown in FIG. **6**, the gaming device **610** can include gaming server resources **608**, a virtualization manager **606**, and operating systems **604***a-d*. The gaming device **600** also includes a sign controller **612**, bank controller **614**, gaming content server **616**, and wide area progressive server **618**, each of which executes using one of the operating systems **604***a-d*.

According to embodiments, the sign controller **612** controls a sign associated with one or more gaming machines/consoles on the network **602**, whereas the bank controller **614** performs control operations for a bank (i.e., a group) of gaming machines on the network **602**. The gaming content server **616** delivers updated gaming content (e.g., audio content, video content, pay tables, etc.) to gaming machines connected to the network **602**, while the wide area progressive server determines progressive jackpots for gaming machines on the network **602**. In one embodiment, the virtualization manager **606** enables all of the servers to operate virtually simultaneously within a single gaming device.

Enhancing Trust

FIG. **7** is a block diagram illustrating a gaming device including a virtualization manager and components for

enhancing trust in the gaming device, according to example embodiments of the invention. In FIG. **7**, the gaming device **700** includes a virtualization manager **706**, which is connected to a trusted platform module **710** and a trusted platform module virtual machine **712**. The virtualization manager **706** is also connected to gaming device resources **708**, operating system **704**A, and operating system **704**B. The operating systems **704**A and **704**B are connected to gaming machine software units **702**A and **702**B, respectively.

As shown in FIG. **7**, in one embodiment, communications between the operating systems **704**A and **704**B and the trusted platform module virtual machine **712** pass through the virtualization manager **706**.

The trusted platform module **710** can be an application specific integrated circuit disposed on a circuit board along with the gaming device's central processing unit. Alternatively, the trusted platform module **710** can be disposed inside the gaming device's central processing unit (see FIG. **9**) or it can be an add-in card. In one embodiment, the trusted platform module **710** includes hardware that is secure from external software attacks and physical theft.

In one embodiment, the trusted platform module **710** includes hardware for generating and storing trusted information, such as keys and digital signatures, which can be used by the operating systems **704**A & **704**B and gaming machine software units **702**A & **702**B. For example, the gaming machine software unit **702**A can use the trusted platform module's keys (or a derivation of its keys) for authenticating data exchanged over a network. In one embodiment, the trusted platform module's trusted information is securely held and only accessible through the trusted platform module virtual machine **712**. Thus, the trusted platform virtual machine **712** limits access to the trusted platform module **710** so that multiple operating systems cannot simultaneously access the trusted platform module's secure information.

According to embodiments, the trusted platform module **710** enables the gaming device **700** to establish a chain of trust for all the gaming device components. For example, the trusted platform module **710** can authenticate and digitally sign the virtualization manager **706** using secure keys. The virtualization manager **706** can, in turn, authenticate and digitally sign the operating systems **704**A & **704**B using the trusted platform module's secure keys (or derivations of the trusted platform module's secure keys). This can continue until all components have been authenticated and digitally signed. Later, the gaming device can verify the digital signatures in an effort to ensure that none of the components have been modified. Operations of embodiments of the gaming device **700** are described below, in the discussion of FIG. **8**.

FIG. **8** is a flow diagram illustrating operations for launching and running a plurality of trusted virtual machines in a gaming device, according to example embodiments of the invention. The operations of the flow **800** will be described with reference to the embodiments shown in FIG. **7**. The flow **800** begins at block **802**.

At block **802**, a trusted platform module virtual machine **712** launches on a gaming device. In one embodiment, the trusted platform module virtual machine **712** launches before any other virtual machines launch. The flow continues at block **804**.

At block **804**, the trusted platform module virtual machine **712** receives an indication that a virtual gaming machine has been launched on the gaming device **700**. In one embodiment, the virtual machine includes the operating system **704**A and the gaming machine software unit **702**A. The flow continues at block **806**.

At block **806**, the trusted platform module virtual machine **712** generates and stores a virtual trusted platform module **714**B, which is associated with the virtual gaming machine. The flow continues at block **808**.

At block **808**, the virtual trusted platform module **714**B provides the operating system **704**B with trusted information, such as trusted keys, passwords, digital certificates, etc. In one embodiment, the virtual trusted platform module **714**B creates the trusted information using secure information stored in the trusted platform module **710**. In another embodiment, the virtual trusted platform module **714**B retrieves and passes-on keys, passwords, and/or digital certificates stored in the trusted platform module **710**. The operating system **704**A can use the trusted information in any suitable matter, including digitally signing data, exchanging keys, verifying digital signatures, etc. The flow continues at block **810**.

At block **810**, the trusted platform module virtual machine **712** determines whether any additional virtual machines will launch. If no additional machines will launch, the flow ends. Otherwise, the flow continues at block **804**.

Example Gaming Devices and Gaming Networks

This section describes example gaming devices and gaming networks with which embodiments of the invention can be practiced. This section also describes example gaming machines.

Example Gaming Device Architecture

FIG. **9** is a block diagram illustrating components of a gaming device, used in conjunction with example embodiments of the invention. As shown in FIG. **9**, the gaming device **906** includes a central processing unit (CPU) **926** connected to a memory unit **928**. According to embodiments, the memory unit **928** can include tangible machine-readable media including instructions for conducting any suitable casino-style wagering game (including bonus events), such as video poker, video black jack, video slots, etc.

The CPU **926** is connected to a network interface unit **924**, which is connected to a gaming network **904**. The CPU **926** is also connected to an input/output (I/O) bus **922**. The I/O bus **922** is connected to a media store **934**, which can be any suitable persistent storage device capable of storing audio and video segments. The media store **934** can be a DVD drive, CD-ROM drive, hard disk drive, semiconductor memory device, or other device suitable for storing media for using in wagering games.

The I/O bus **922** is also connected to payout mechanism **908**, secondary display **910**, primary display **912**, money/credit detector **914**, touchscreen **916**, post-buttons **718**, and information reader **720**. The I/O bus **722** facilitates communication between the system components and the CPU **726**.

According to some embodiments, the gaming device **906** can include additional peripheral devices and/or more than one of each component shown in FIG. **9**. For example, in one embodiment, the gaming device **906** can include multiple network interface units **924** and multiple CPUs **926**. Additionally, the components of the gaming device **906** can be interconnected according to any suitable interconnection architecture (e.g., directly connected, hypercube, etc.).

In one embodiment, the gaming device **906** can be connected with a plurality gaming consoles for conducting a plurality of wagering games. In another embodiment, the gaming device **906** can run a plurality of gaming servers and controllers. In yet another embodiment, the gaming device can be employed as a gaming machine for conducting wager-

ing games. Gaming machines are described in more detail below, in the discussion of FIG. **8**.

Example Gaming Machine

FIG. **10** is a perspective view of a gaming machine, according to example embodiments of the invention. As shown in FIG. **10**, the gaming machine **1000** can be a computerized slot machine having the controls, displays, and features of a conventional slot machine.

The gaming machine **1000** can be mounted on a stand **1042** or it can be constructed as a pub-style tabletop game (not shown). As a result, the gaming machine **1000** can be operated while players are standing or seated. Furthermore, the gaming machine **1000** can be constructed with varying cabinet and display designs. The gaming machine **1000** can incorporate any primary game such as slots, poker, or keno, and additional bonus round games. The symbols and indicia used on and in the gaming machine **1000** can take mechanical, electrical, or video form.

As illustrated in FIG. **10**, the gaming machine **1000** includes a coin slot **1002** and bill acceptor **1024**. Players can place coins in the coin slot **1002** and paper money or ticket vouchers in the bill acceptor **1024**. Other devices can be used for accepting payment. For example, credit/debit card readers/validators can be used for accepting payment. Additionally, the gaming machine **1000** can perform electronic funds transfers and financial transfers to procure monies from financial accounts. When a player inserts money in the gaming machine **1000**, a number of credits corresponding to the amount deposited are shown in a credit display **1006**. After depositing the appropriate amount of money, a player can begin playing the game by pushing play button **1008**. The play button **1008** can be any play activator used for starting a wagering game or sequence of events in the gaming machine **1000**.

As shown in FIG. **10**, the gaming machine **1000** also includes a bet display **1012** and one or more "bet" buttons on the panel **1016**. The player can place a bet by pushing one or more of the bet buttons on the panel **1016**. The player can increase the bet by one or more credits each time the player pushes a bet button. When the player pushes a "bet one" button **1016**, the number of credits shown in the credit display **1006** decreases by one credit, while the number of credits shown in the bet display **1012** increases by one credit.

A player may end the gaming session or "cash-out" by pressing a cash-out button **1018**. When a player cashes-out, the gaming machine **1000** dispenses a voucher or currency corresponding to the number of remaining credits. The gaming machine **1000** may employ other payout mechanisms such as credit slips (which are redeemable by a cashier) or electronically recordable cards (which track player credits), or electronic funds transfer.

The gaming machine also includes a primary display unit **1004** and a secondary display unit **1010** (also known as a "top box"). The gaming machine may also include an auxiliary video display **1040**. In one embodiment, the primary display unit **1004** displays a plurality of video reels **1020**. According to embodiments of the invention, the display units **1004** and **1010** can include any visual representation or exhibition, including moving physical objects (e.g., mechanical reels and wheels), dynamic lighting, and video images. In one embodiment, each reel **1020** includes a plurality of symbols such as bells, hearts, fruits, numbers, letters, bars or other images, which correspond to a theme associated with the gaming machine **1000**. Additionally, the gaming machine **1000** also includes an audio presentation unit **1028**. The audio presentation unit **1028** can include audio speakers or other suitable sound projection devices.

In one embodiment, the gaming machine **1000** can include a virtualization manager for sharing resources between a plurality of operating systems, as further described herein.

Example Gaining Network

FIG. **11** is a block diagram illustrating a wagering game network, according to example embodiments of the invention. In some embodiments, the gaming devices described above can be part of a wagering game network.

As shown in FIG. **11**, the wagering game network **1100** includes a plurality of casinos **1118** connected to a communications network **1114**. Each of the plurality of casinos **1118** can include local area networks, which include a plurality of gaming machines **1102** connected to a game server **1120**. The game server **1120** includes a virtualization manager **1122**. In one embodiment, the gaming server **1120** and gaming machines **1102** include tangible machine-readable media including instructions for performing operations for sharing resources between a plurality of operating systems, as described herein.

The components of each casino **1118** can communicate over wired **1110** and/or wireless connections **1112**. Furthermore, they can employ any suitable connection technology, such as Bluetooth, 802.11, Wireless Application Protocol (WAP), Ethernet, public switched telephone networks, etc.

General

In this description, numerous specific details are set forth. However, it is understood that embodiments of the invention may be practiced without these specific details. In other instances, well-known circuits, structures and techniques have not been shown in detail in order not to obscure the understanding of this description. Note that in this description, references to "one embodiment" or "an embodiment" mean that the feature being referred to is included in at least one embodiment of the invention. Further, separate references to "one embodiment" in this description do not necessarily refer to the same embodiment; however, neither are such embodiments mutually exclusive, unless so stated and except as will be readily apparent to those of ordinary skill in the art. Thus, the present invention can include any variety of combinations and/or integrations of the embodiments described herein. Each claim, as may be amended, constitutes an embodiment of the invention, incorporated by reference into the detailed description.

Herein, block diagrams illustrate example embodiments of the invention. Also herein, flow diagrams illustrate operations of the example embodiments of the invention. The operations of the flow diagrams are described with reference to the example embodiments shown in the block diagrams. However, it should be understood that the operations of the flow diagrams could be performed by embodiments of the invention other than those discussed with reference to the block diagrams, and embodiments discussed with references to the block diagrams could perform operations different than those discussed with reference to the flow diagrams. Additionally, some embodiments may not perform all the operations shown in a flow diagram. Moreover, although the flow diagrams depict serial operations, certain embodiments could perform certain of those operations in parallel.

The invention claimed is:

1. A computer-implemented method of conducting a wagering game on a gaining system, operations of the wagering game being split between a first gaming application executing on a first operating system (first O/S) and a second gaming application executing on a second operating system (second O/S), the gaming system including a virtualization manager enabling communication between and sharing gaming device resources between the first O/S and the second O/S, the method comprising:

receiving, via at least one input device, a wager from a player initiating the wagering game;

determining, via one or more processors executing the first application, an outcome of the wagering game;

communicating, via the virtualization manager, the outcome determined by the first application to the second application;

generating, via the second application, one or more game images representing the outcome; and

displaying, via one or more display device resources, the one of more game images to the player.

2. The method of claim 1, wherein the one or more processors includes at least a first processor running the first O/S and a second processor running the second O/S.

3. The method of claim 1, wherein input device resources, including the at least one input device, and output device resources including the one or more display devices, utilized by the wagering game are controlled by one or more gaming device applications running on the second O/S.

4. The method of claim 1, wherein the virtualization manager comprises a module executed by the one or more processors.

5. The method of claim 1, further comprising:

receiving a second wager from a second player to initiate another wagering game, the another wagering game being initiated during play of the at least one wagering game, operations of the another wagering game being split between the first application on the first O/S and a third application on a third O/S;

determining , via the first application, another outcome of the another wagering game;

communicating the another outcome from the first application to the third application;

generating, via the third application, one or more additional game images representing the another outcome; and

displaying the one or more additional game images to a player on he one or more display devices.

6. The method of claim 1, wherein the virtualization manager further receives requests for gaming device resources from the first O/S and the second O/S, and allocates the gaming device resources to the first O/S and second O/S.

7. A gaming system configured to conduct at least one wagering game, operations of the at least one wagering game being split between a first application executing on a first operating system (first O/S) and a second application executing on a second operating system (second O/S), the gaming system comprising:

at least one input device for receiving a wager from a player to initiate the at least one wagering game;

one or more display devices;

a virtualization manager enabling communication and sharing gaming device resources between the first O/S and the second O/S;

one or more processors executing the first application on the first O/S and the second application on the second O/S; and

at least one memory device storing instructions that, when executed by the one or more processors, cause the gaming system to:

receive the wager to initiate the at least one wagering game;

determining, via the first application on the first O/S, an outcome of the at least one wagering game;

communicate, via the virtualization manager, the outcome determined by the first application to the second application;

generate, via the second application on the second O/S, one or more game images representing the outcome; and

display the one or more game images to the player on the one or more display devices.

8. The gaming system of claim 7, wherein input device resources, including the at least one input device, and output device resources, including the one or more display devices, utilized by the at least one wagering game are controlled by one or more gaming device applications running on the second O/S.

9. The gaming system of claim 7, further comprising:

receiving a second wager from a second player to initiate another wagering game, the another wagering game being initiated during play of the at least one wagering game, operations of the another wagering game being split between the first application on the first O/S and a third application on a third O/S;

determining, via the first application on the first O/S, another outcome of the another wagering game;

communicating the another outcome from the first application to the third application;

generating, via the third application on the third O/S, one or more additional game images representing the another outcome; and

displaying the one or more additional game images to a player on the one or more display devices.

10. The gaming system of claim 7, further comprising a game server connected to a communications network, and wherein the at least one memory device resides on the game server.

11. The gaming system of claim 7, wherein the virtualization manager comprises a module stored on the at least one memory device and executed by at least one of the one or more processors.

12. The gaming system of claim 7, further comprising a trusted platform module, wherein the virtualization manager includes a trusted platform virtual machine (TPVM), the virtualization manager is authenticated using secure authentication data from the trusted platform module, and the TPVM authenticates the first O/S and the second O/S via the secure authentication data from the trusted platform module.

13. A machine-readable, non-transitory medium configured to conduct at least one wagering game on a gaming system, operations of the at least one wagering game being split between at least a first application executing on a first operating system (first O/S) and a second application executing on a second operating system (second O/S), the gaming system including a virtualization manager that enables communication between the first O/S and the second O/S, the medium including executable instructions that, when executed by one or more processors, cause the gaming system to perfbrm a method comprising:

receiving, via at least one input device, a wager from a player initiating the at least one wagering game;

determining , via the one or more processors executing the first application on the first O/S, an outcome of the at least one wagering game;

communicating, via the virtualization manager, the outcome determined by the first application to the second application;

generating, via the one or more processors executing the second application on the second O/S, one or more game images representing the outcome; and

displaying, via one or more display devices, the one or more game images to the player.

14. The medium of claim **13**, wherein the one or more processors includes at least a first processor executing the first O/S and a second processor executing the second O/S.

15. The medium of claim **13** wherein the virtualization manager further receives requests for gaming device resources from the first O/S and the second O/S, and allocates the gaming device resources to the first O/S and second O/S.

16. The medium of claim **13**, wherein input device resources, including the at least one input device, and output device resources including the one or more display devices, utilized by the wagering game are controlled by one or more gaming device applications running on the second O/S.

17. The medium of claim **13**, wherein the gaming system further comprises a game server connected to a communications network, and wherein the medium resides on the game server.

18. The medium of claim **13**, wherein the gaming system further comprises a plurality of gaming machines, each gaming machine comprising a corresponding input device and display device, wherein the at least one wagering game includes a separate wagering game initiated on each gaming machine of the plurality as well as a separate secondary O/S for each separate wagering game, and wherein a separate outcome for each separate wagering game is determined via the first application running on the first O/S, and game images representing each separate outcome are generated via various applications running on the secondary O/S's.

19. The medium of claim **13**, wherein the virtualization manager comprises a module stored on the at least one memory device and executed by at least one of the one or more processors.

20. The medium of claim **13**, the gaining system further comprising a trusted platform module, wherein the virtualization manager includes a trusted platform virtual machine (TPVM), the virtualization manager is authenticated using secure authentication data from the trusted platform module, and the TPVM authenticates the first O/S and the second O/S via the secure authentication data from the trusted platform module.

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